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(71)(72) Applicant and Inventor: URQUHART, John, Charles [GB/CH]; 21 Granary Street, Burghead, Elgin IV30 2UJ (GB).

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(54) Title: POTASSIUM SILICATE DRILLING FLUID

(57) Abstract

An aqueous drilling fluid for use in drilling through reactive clays and shales and other soft formations e.g. chalk, contains in addition to typical polymeric agents for fluid loss control and rheological control, a stabiliser consisting essentially of a range of exclusively potassium silicates i.e. containing silica and potassium oxide in various ratios, but no bentonite or barite or other solids weighting material and is free of brine solutions commonly used in prior art drilling fluids.

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# POTASSIUM SILICATE DRILLING FLUID

## Field of the invention

This invention relates to drilling and more particularly to the drilling fluids used in the drilling of wells in the search for oil, gas and water or in the completion of oil, gas and water wells.

## Background of the invention

A particular problem is encountered while drilling through reactive clays and shales and other soft formations e.g. chalk. Typical water based drilling fluids may cause reactive clays and shales to swell which can cause severe drilling problems which can lead to the abandonment of the well. Oil based drilling fluids are used to prevent clays and shales swelling, but are a source of environmental problems.

## Background art

US-A-3 640 343 proposed the use of a water-soluble sodium silicate in the stabilisation of hard shaly earth formations by forcing fluids containing said silicate deep into the shaly earth formations. Numerous other patents refer to use of alkali metal salts as components having adjuvant or auxiliary additive functionality in drilling fluids and amongst these the following may be referred to as illustrative of the art:

US-A-2 146 693, US-A-2 165 823/4, US-A-3 259 189, US-A-3 738 437, US-A-3 679 001, US-A-4 988 450, US-A-4 525 285, US-A-5 211 250; SU-A-1 199 786.

It is generally the case that the use of alkali metal salts in the known drilling fluids involves relatively small amounts in conjunction with many other components such as solids weighting agents, thickeners, rheology modifiers, and miscellaneous organic shale stabilisers often of a polyfunctional polymeric species.

## Objects of the invention

An object of the present invention is to obviate or mitigate the aforesaid disadvantages of known drilling problems in drilling operations carried upon reactive clays

and shales and other soft formations. A further object is to provide a drilling fluid useful in drilling operations in soft formations.

## Summary of the invention

According to the present invention there is provided an aqueous drilling fluid containing a proportion of polymeric agents for fluid loss control and rheological control, and an amount of alkali metal silicate *characterised in that* the alkali metal silicate content consists essentially of a range of potassium silicates i.e. containing silica and potassium oxide in various ratios.

The most preferred fluid consists essentially of water containing from 28 to 35% by weight of potassium silicate wherein the silica ($SiO_2$) content is from 20 to 40% by weight and the potassium oxide ($K_2O$) content is from 8 to 15% by weight.

The polymeric agents for fluid loss control and rheological control may be selected from cellulose based polymers, e.g. carboxymethyl cellulose and xanthan gums but this preference does not exclude the use of other polymeric species having equivalent properties. Preferred amounts include from 3 to 6 $kg/m^3$ of viscosity modifier and from 1 to 3 $kg/m^3$ of fluid loss inhibitor. Suitable polymeric materials are commercially available as proprietary materials for the purposes stated.

The most preferred fluids exhibit viscosities in the range of 35 - 50 mPas at 20 C (as measured on a Fann 35 rheometer).

Fluids of this invention surprisingly exhibit fluid loss of below 4 mls on the API standard fluid loss test wherein drilling fluid is placed in the standard filter press cup at a pressure of 100 psi ($6.89 \times 10^5$ Pa) for 30 minutes. That test provides an indication of the life expectancy or circulation loss performance to be obtained in use of the fluid in a porous formation. In fact the preferred fluids of this invention exhibit <u>zero</u> fluid loss in this standard test which is a result which was hitherto inconceivable at the levels of polymer additives utilised in

this invention. Typical drilling fluids forming the state of the art till now exhibit fluid loss of no better than about 8 to 10 mls in such a test and that is attainable only through use of from 20 kg/$m^3$ of polymer and 75 kg/$m^3$ of bentonite.

There is therefore provided by this invention a reliable method of drilling and consolidating a borehole in a shale, chalk or similar soft formation wherein during a drilling operation there is introduced an aqueous drilling fluid comprising an amount of alkali metal silicate wherein the alkali metal silicate content consists essentially of a range of potassium silicates, and a proportion of polymeric agents for fluid loss control and rheological control thereby providing for substantially zero fluid loss and a viscosity of from 35 - 50 mPas at 20 C.

Best mode for carrying out the invention

An example of the preferred compositions of drilling fluid according to the invention is now described in order to more clearly illustrate the nature of the invention.

Example

| Component | % by weight |
|---|---|
| Potassium Silicate | 29.75 |
| $SiO_2$ content | 21.30 |
| $K_2O$ content | 8.45 |
| Water | 70 |
| pH | 11.2 - 11.4 |
| Fluid enhancing additives: | |
| Viscosity Modifier | 3 - 6 kg/$m^3$ |
| Fluid Loss Inhibitor | 1 - 3 kg/$m^3$ |

The fluid just described is made by forming a suitable potassium silicate solution within the ranges specified herein e.g. as above of about 30% by weight potassium silicate of a preselected mole ratio of $SiO_2$ to $K_2O$ and about 70 % by weight water, and slowly adding the selected viscosity modifier and fluid loss inhibitor agents through a mixing hopper into a tank of the potassium silicate solution. The physical properties of the drilling fluid

such as viscosity and especially the density can be selectively varied by introducing potassium silicate of differing mole ratio as a powder e.g. obtainable by spray drying of a selected potassium silicate solution.

## Industrial applicability

The introduction of a potassium silicate drilling fluid according to the invention during the drilling operation offers significant advantages which are attributable to the unexpectedly advantageous properties arising from the selection of potassium silicate as the main stabilising component and these advantages include the following:

1) water based fluid which is non-toxic;
2) the heaving of shale is prevented;
3) the swelling of clays is inhibited, the dispersion of clays is prevented and clay and other weak formations are hardened sufficiently to meet operational requirements; and
4) the borehole becomes essentially sealed with a coating by the fluid which can prevent the invasion of filtrate.

The invention allows re-consideration of accessing soft formation sites previously abandoned due to troublesome working or rejected as too costly to work due to repeated borehole collapse.

The fluid of the present invention also tends to repel solids rather than entrain them as observed with prior art such as Darley (US-A-3 640 343).

It is notable that the fluid of this invention contains no bentonite or barite or other solids weighting material and is free of brine solutions commonly used in prior art drilling fluids. The fluid of this invention also requires significantly less polymer content than prior formulations yet on the API fluid loss test a fluid loss of zero is achievable.

## CLAIMS

1. An aqueous drilling fluid containing a proportion of polymeric agents for fluid loss control and rheological control, and comprising an amount of alkali metal silicate wherein the alkali metal silicate content consists essentially of a range of potassium silicates i.e. containing silica and potassium oxide in various ratios.

2. A fluid according to claim 1 comprising from 28 to 35% by weight of potassium silicate wherein the silica ($SiO_2$) content is from 20 to 40% by weight and the potassium oxide ($K_2O$) content is from 8 to 15% by weight.

3. A fluid according to claim 1 or claim 2 wherein the viscosity of the fluid lies in the range of 35 - 50 mPas at 20 C.

4. A fluid according to claim 1 or claim 2 wherein the fluid loss is below 4 mls on the API fluid loss test.

5. A fluid according to claim 1 or claim 2 wherein the polymeric agents are selected from the group consisting of cellulose based polymers and xanthan gums.

6. A fluid according to claim 1 or claim 2 wherein the amount of polymeric agent providing viscosity control is from 3 to 6 $kg/m^3$ of fluid.

7. A fluid according to claim 1 or claim 2 wherein the amount of polymeric agent providing fluid loss control is from 1 to 3 $kg/m^3$ of fluid.

8. A method of drilling and consolidating a borehole in a shale, chalk or similar soft formation wherein during a drilling operation there is introduced an aqueous drilling fluid comprising an amount of alkali metal silicate wherein the alkali metal silicate content consists essentially of a range of potassium silicates, and a proportion of polymeric agents for fluid loss control and rheological control.

9. A method according to claim 6 wherein the fluid contains from 28 to 35% by weight of potassium silicate wherein the silica ($SiO_2$) content is from 20 to 40% by weight and the potassium oxide ($K_2O$) content is from 8 to 15% by weight.

10. A method of producing a drilling fluid comprising providing an aqueous solution of potassium silicate having a selected molar ratio of $K_2O$ to $SiO_2$, adding selected viscosity and fluid loss agents thereto, and adding, in powdered form, predetermined amounts of at least one further potassium silicate of differing molar ratio of $K_2O$ to $SiO_2$ from that already in solution to obtain a fluid of a selected density.

# INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 95/00731

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C09K7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | EP,A,0 333 458 (E.I.DU PONT DE NEMOURS) 20 September 1989 cited in the application | 1,8 |
| A | see page 4, line 7 - line 28 | 2 |
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| Y | US,A,5 358 044 (A.H.HALE) 25 October 1994 see column 16, line 17 - line 62 | 1,6-8 |
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| Y | DATABASE WPI Derwent Publications Ltd., London, GB; AN 92-389283 & SU,A,1 699 991 (MOSC.GUBKIN OIL GAS INST.) see abstract | 1,5 |
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